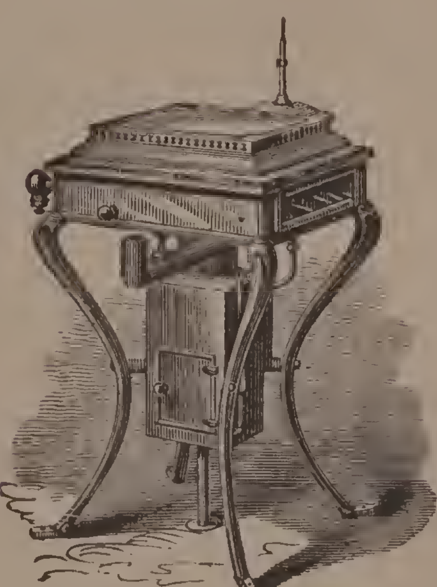
THE MAXIM

GAS MACHINE,



DESCRIBED AND COMPARED.

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INTRODUCTION.

The Maxim Gas Machine Company do not pretend, that in publishing this pamphlet they are influenced by any other motive than that of advertising their own business. Nevertheless, they invite the closest investigation and inquiry into the statements herein contained.

They have been careful throughout to ask the reader to believe as little as possible upon their bare assertions, but have preferred to give as plain and straightforward an elucidation of the nature of gasoline, and of the laws affecting its evaporation and subsequent solution in air, in the form of air-gas, as the scope of this pamphlet would permit, so that the reader might be able to make his own deductions and form his own conclusions.

Most of these intending to purchase gas machines are already acquainted with the general laws and principles here laid down, and know them to be correct, and those who are not have among their friends those fully competent to judge of such matters.

To these The Maxim Gas Machine Company would say: Take nothing for granted because we assert it. We do not pretend to do more than give your inquiries a proper direction, and where we make assertions we invariably deduce them from well known chemical and physical laws, which we have merely quoted, as they are to be found in any elementary work upon chemistry or natural philosophy.

PORTABLE GAS MACHINES.

(1.) Up to the time of the discovery of petroleum the substances mostly employed for the manufacture of gas on a small scale were oil, refuse fat and resin—the latter being much used even in small towns—but the use of these substances is attended with more trouble than the public generally are willing to take, and requires more skill than most people possess, so that on the whole preference was given to lamps and candles.

(2.) The discovery of pretroleum has, however, afforded a new and apparently inexhaustible supply of a cheap gas-producing material requiring no skill in its manipulation, and affording a light which in brilliancy and beauty surpasses that produced by the best coal gas. This material is one of the most volatile products of the distillation of pretroleum, and is called *gasoline.*

(3.) For the purpose of converting gasoline into gas in the most perfect and reliable manner, and with least trouble and expense, many devices have been used, and much ingenuity and skill, and a large amount of labor and capital have been expended. This is sufficiently attested by the records of the patent office, which show that in the United States alone nearly two hundred patents have been issued for gas machines and processes relating to the manufacture of gas from gasoline. These, however, are all embraced in and may be reduced to three systems.

(4.) One application of gasoline to the purposes of illumination is to manufacture hydrogen gas by any known process, and by some suitable device to force this gas over or through gasoline, or some porous or fibrous material saturated with it, by which means the hydrogen, which has no illuminating power of its own, becomes saturated with the rich hydrocarbon vapors of the gasoline, and is thus converted into an illuminating agent equal to the best coal gas.

(5.) The second system of making gas from gasoline embraces all those devices by means of which a current of common air is forced over or through gasoline, or some porous or fibrous material saturated or impregnated with it, by which means the air becomes carburetted, that is to say impregnated with the rich hydrocarbon vapors of the gasoline to such an extent as to admit of its being used like ordinary coal gas for the purposes of light and heat.

(6.) The third and *latest* system is to convert the gasoline into

vapor or gas by the application of external heat, and then by suitable mechanical means to mix the gas or vapor so formed with any desired proportion of air.

GASOLINE.

(7.) GASOLINE is one of the lightest products of the distillation of petroleum. It is really a light naphtha, and was originally given its distinctive appellation of gasoline principally for the purpose of evading the internal revenue tax upon naphtha.

PETROLEUM.

(8.) PETROLEUM cannot be said to be a homogeneous substance, but must be looked upon rather as a mixture of an indefinite, and apparently unlimited variety of similarly constituted compounds. So interminable indeed is the number of these compounds, and so infinitesimal are the shades of difference between each member of the series and the next in the order of succession, that the only practical method of classifying them has been to group the products of distillation into classes, according to their specific gravities, designating the members of the series belonging to each class by one generic name.

(9.) When petroleum is subjected to distillation the lightest and most volatile of the substances which compose it distil over at first, the products growing heavier and less volatile as the distillation proceeds and the heat is increased; and it is by taking advantage of this circumstance that the distiller is enabled to separate the several oils of which it is composed according to any desired classification, the lines of demarkation being determined by the specific gravity of the liquid which distils over. This is what is known by *fractional distillation.*

(10.) The classification usually adopted by distillers is as follows:

	Specific Gravity.	Beaume Hydrometer.	
All below	.664	above 88°	is called Chymogene.
" from	.664 to .705	88° to 70°	is called Gasoline.
" "	.705 " .745	70° " 60°	" " Naphtha.
" "	.745 " .785	60° " 50°	" " Benzine.
" "	.785 " .854	50° " 35°	" " Kerosene.
" "	.854 " .953	35° " 28°	" " Lubricating Oil.

GASOLINE.

(11.) Gasoline then, is composed of these portions of the crude petroleum whose densities range between .664 and .705 degrees specific gravity, and 88° and 70° Beaume hydrometer. It is a very clear and exceedingly limpid liquid, with a slight, but not disagreeable odor of petroleum—has an average specific

gravity of about .680—two thirds the weight of water—and is very volatile, its boiling point being about 65° Fahrenheit's thermometer. It is this low boiling point and consequent property of evaporating rapidly at ordinary temperatures which renders it peculiarly available for making air-gas.

(12.) You will now see that when you buy a barrel of gasoline at 85° it is not *all* 85°, but that this is merely its *average* gravity. You will see, too, that like the petroleum from which it is derived, it is capable of being divided by fractional distillation in a series of liquids, having different boiling points and specific gravities, for as distillation or evaporation of the mass proceeds the lighter and more volatile portions of the fluid distil over first, while the remaining liquid continually grows heavier and less volatile, and consequently of less value for making air-gas.

(13.) From the very nature of gasoline itself, it must now be evident that, in selecting a gas machine, you should choose one the construction and operation of which are such as to prevent the evaporation and absorption of the lighter and more valuable parts of the gasoline at first, and the consequent deterioration of the remaining liquid to such a degree, that (as often happens) a great portion of it has to be thrown away as utterly worthless for gas making.

(14.) You need scarcely be told, *that in order to be of uniform quality, your gas must be made under uniform conditions*—one of the most essential being *uniformity in the quality of the material from which it is made.* How is this uniformity to be maintained? In the first place, by buying your gasoline of uniform quality, and, in the second, by using a machine into which it is introduced gradually and in small quantities, and only as it is used—a machine which is capable of using up every drop that enters it, and does not allow any gasoline that has once entered it to return to your reservoir, to mix with your remaining supply and deteriorate its quality. You must be careful that the supply of gasoline in your reservoir will not have its lighter and more valuable parts used up at first, but will continue of uniform quality from the beginning to the end, thereby *insuring uniformity in the quality of your gas.*

EVAPORATION.

(15.) Having been told so much of the nature of gasoline itself, you may now wish to learn something of the phenomena attending its conversion into vapor or gas, and the laws which govern the solution and absorption of this vapor by air or whatever other menstruum may be used.

(16.) By *evaporation of a liquid* is meant its conversion into

vapor. Most liquids are capable of giving off vapor at nearly every temperature, *the extent and rapidity of the process being invariably augmented by heat.*

(17.) The *boiling point* of liquids is that temperature at which they boil, under the usual atmospheric pressure, 30 inches of mercury. This temperature differs for different liquids—the boiling point of water being 212° of Fahrenheit's thermometer, while (sec. 11) that of gasolime, is about 65°. At 30 inches barometrical pressure you cannot heat water beyond 212°, but if you continue to apply heat after it has reached that temperature you will convert it all into vapor or steam.

(18.) Now, suppose you measure a gallon of water and apply heat until it has been all evaporated, you will find that the quantity of heat which it has taken to evaporate the water has been about five times as much as would have been required to raise its temperature from the freezing to the boiling point. The thermometer will not detect any excess of temperature over 212° in either the water or the steam, and yet the heat is contained in the steam, having been absorbed and rendered *latent* in it at the moment of its formation.

(19.) Whenever a liquid is converted into vapor, by any process whatever, a large amount of heat is absorbed and rendered latent in the vapor at the instant of its formation. Such absorption *being an absolute condition* of the change of form which the liquid undergoes, and because the presence of this heat in the vapor cannot be detected by the thermometer, it is called *latent or hidden heat.*

(20.) In the experiment described (sec. 18) external heat has been applied, and the heat necessary to the evaporation of the water has been derived from that source. Suppose, now, that instead of applying external heat you employ other means of evaporation, and see what the effect will be. Suppose, by means of an air-pump, you form and maintain a vacuum under a receiver containing some volatile liquid; you can thus produce evaporation as rapidly as by the application of external heat.

(21.) *As an absolute essential of its formation and existence* every atom of vapor formed must absorb and render latent within it a certain amount of heat (sec. 19). You have seen that the water has drawn this heat from an external source (sec. 18). In the present experiment no external heat is applied and the inevitable consequence will be that the heat necessary to the formation of the vapor *must be derived from the remaining liquid.* This is in truth the plan usually pursued in the artificial production of ice. The cold produced by the evaporation of one or another volatile liquid is so intense, that water is instantly frozen, and it is now

proposed by the same means to convert the holds of ships into huge refrigerators, and thus transport whole cargoes of fresh meat, in a frozen state, between the most distant parts of the world.

(22.) Exactly the same effects take place when a rapid and continuous current of air, or some other evaporating medium is forced through a volatile liquid, or through a porous or fibrous material, saturated therewith; the inevitable result being a rapid evaporation and a corresponding depression of temperature.

(23.) In a word, rapid and continued evaporation, in whatever manner produced, cannot take place without producing great depression of temperature in the remaining liquid, and *the heat absorbed by the vapor must be restored from some external source, or the depression of temperature induced will inevitably check altogether the evaporation which has produced it.*

CAPACITY OF LIQUIDS FOR MOISTURE.

(24.) Depression of temperature not only checks evaporation, but it also lessens, in a most extraordinary degree, the capacity of air or other gaseous menstruum for *retaining* vapor already absorbed and held in solution. It is well known that the capacity of air or gases for dissolving and retaining in solution other substances is increased or diminished by every increase or diminution of temperature, but few persons are aware of the extent to which this effect takes place. Professor Leslie says, "That while the temperature itself advances uniformly in arithmetical progression, the dissolving power which this communicates to the air mounts with the accelerating rapidity of a geometrical series," as shown by the table:

(25.)

Temperature of the air.		Saturating weight of moisture.
32°	Fahrenheit	........1-150th.
59°	"	........1-80th.
86°	"	........1-40th.
113°	"	........1-20th.
140°	"	........1-10th.

Thus it will be seen, that rapid and continued evaporation not only deprives the evaporating medium of its calorie, so as to check all further formation of vapor, but, at the same time, the depression of temperature produced must deprive it to a great extent of its capacity for retaining in solution vapor already formed and absorbed.

REQUISITES OF A GOOD GAS MACHINE.

(26.) Having inquired into the nature of the material used, and the laws by which its evaporation and conversion into illuminating gas are governed, let us now see what the requisites of a

good gas machine are. It should be SAFE, RELIABLE, ECONOMICAL, DURABLE, COMPACT and SIMPLE, and moreover, should not be productive of any effects injurious to health; these being absolute requirements to which every good gas machine should conform, and constituting a fair and safe standard by which to judge of the respective merits of the several systems of gas making in use.

HYDROGEN MACHINES.

(27.) The process of making hydrogen gas in portable gas machines is simply this. Iron turnings are dissolved in sulphuric acid, diluted with five or six times its bulk of water. The iron and acid combine with oxygen derived from the decomposition of a portion of the water, and form sulphate of iron or copperas, while the hydrogen of the decomposed water is set free. By a simple arrangement of the machine, gas is prevented from being formed faster than it is required for use, and as fast as formed is forced over or through a mass of porous or fibrous material, saturated with gasoline. The gas produced gives a rich, clear and beautiful light, fully equal if not superior to the best coal gas.

(28.) A great many devices have been patented for making illuminating gas by dissolving hydrocarbon vapors in hydrogen, but without a single exception they have all been modifications of the well known philosophical lamp invented by Dr. Hare, some forty years ago. A good deal of money has been made *by selling these patents*, but none of the patentees have attempted to make a business of *making and selling machines*, which is the very best evidence in the world that they have no faith in their own devices, and that for all practical purposes they are an utter failure.

THE GAS COSTS TOO MUCH.

(29.) It has been stated (27) that hydrogen gas is usually produced by the decomposition of water, by means of sulphuric acid and iron, which is strictly a chemical process. Now, it is a well established chemical fact that different forms of matter can enter into combination with each other only in certain definite and well ascertained proportions, which are termed the combining *equivalents* of these bodies.

(30.) The combining equivalents and cost of sulphuric acid, iron and water are about as follows:

49 lbs. sulphuric acid, @ 3c.	$1 47
28 " iron turnings, " 1c.	0 28
9 " water	0 00
	$1 75

Let us now see how much hydrogen gas can be made from the

above materials. Nine pounds of water contain exactly one pound = 7,000 grains of hydrogen gas, which is all that can *possibly* be made from its decomposition. Now, 100 cubic inches of hydrogen gas weigh 2,116 grains. Therefore, $\frac{7,000 \times 100}{2,116}$ will give 330,813 cubic inches = 191$\frac{1}{3}$ cubic feet of hydrogen gas, at a cost of \$1.75.

(31.) This is merely the theoretical result; but in practice, and especially in the hands of those who are not experts, 75 per cent. of the above may be considered a fair yield, for it must be remembered that even in the hands of an expert practical man results seldom come fully up to the theoretical yield. Therefore, $191\frac{1}{3} \times \frac{3}{4}$ will give 143$\frac{1}{2}$ cubic feet of hydrogen gas, at a cost of \$1.75, which is at the rate of \$12.19 per 1,000 cubic feet.

(32.) One thousand cubic feet of hydrogen gas will be increased to about 1,250 feet by the absorption of the vapor from nine gallons of gasoline, worth about \$2; so, by adding the cost of the gasoline to that of the hydrogen, we have \$14.19 as the cost of 1,250 cubic feet of gas, which is at the rate of \$11.27 per 1,000.

HYDROGEN MACHINES ARE UNSAFE.

(33.) They require a great deal of handling, emptying, filling, &c.; and a reference to the report of the Committee on Gas Machines to the New York Board of Fire Underwriters, adopted October 20th, 1869, will show that herein lies the chief element of danger.

HYDROGEN MACHINES ARE NOT PRACTICAL OR RELIABLE.

(34.) From the great expense of running hydrogen machines, and their extremely small capacity, in proportion to the great bulk of material requiring to be handled, they have been used as philosophical toys, or for experiment, more than for any practical purpose. Indeed, their capacity is so limited, that it is very doubtful whether one of them has ever been made capable of running twenty burners for twelve consecutive hours. *They do very well to show a few lights and to sell patent rights with*, but beyond this there is nothing in them. Consider for a moment that it requires 280 lbs. (nearly two carboys) of sulphuric acid, 200 lbs. of iron borings, and about two barrels of water to make 1,000 feet of hydrogen gas.

(35.) Who would have all this about his house, especially when it is borne in mind that every time the machine is opened to renew the charge, all this refuse has to be removed, and is sure to evolve a large volume of sulphureted hydrogen gas, which fills the entire house and premises with a nauseous odor resembling that of rotten eggs, and moreover has the pleasant property

of tarnishing gilding and silver-ware and destroying mineral paints and dyes?

THE GAS IS UNHEALTHY.

(36.) It must be remembered that none but a very impure acid can be bought for three cents, the pure acid being worth eight or ten times as much. The greater part of the cheap sulphuric acid of commerce is made from iron pyrites, which it is well known are scarcely ever found free from arsenic, and consequently the sulphuric acid made from them is largely contaminated with this metal, which impregnates the gas and is carried over into the flame, where it is converted by combustion *into the white arsenic so well known as a virulent poison.* It is scarcely necessary to say that the inhalation of air contaminated by its presence must be injurious to health.

(37.) From the foregoing considerations it must be evident that hydrogen machines cannot be looked upon us as ECONOMICAL, PRACTICAL, SAFE or RELIABLE; and, if there were no other proof of this, it is to be found in the fact, that the proprietors of these machines are all very anxious to sell patent rights, *while few if any of them care to pursue the legitimate business of making and selling machines.*

AIR-GAS MACHINES.

(38.) Let us now turn to the system of carbureting air by forcing it over or through gasoline, or over or through some porous or fibrous material saturated therewith. Machines of this sort may be divided into two classes—being these which rely solely upon the air to furnish the necessary caloric (secs. 19 and 23) and those which supplement the atmospheric temperature by the application of external heat. *Let us now see whether it is possible to make a* SAFE, RELIABLE and ECONOMICAL gas machine upon this system, either with or without the application of external heat.

(39.) To save trouble, let us admit that the hundred and fifty or more machines of this class are all perfect in their construction and operation. Let us admit everything else that is claimed for them, and let us come at once to the main questions of SAFETY, ECONOMY and RELIABILITY. *Is every element of danger removed or controlled? Do they manufacture gas as cheaply as it can be made from the materials used? Can they make gas at all in cold weather? Will they make gas continuously and of uniform quality in any weather? Is it possible to make a thoroughly reliable gas machine upon this plan?*

AIR-BLOWING MACHINES ARE NOT SAFE.

(40.) Because they usually contain large quantities of gasoline. Because they require a great deal of attention, during which the

gasoline undergoes much handling, filling, drawing off residuum, &c. *Because they are absolutely unable to control the relative proportions of gas and air*, so that when burning but few lights in warm weather, and even in cold weather, when external heat is applied they are liable to accidents (sec. 53).

AIR-BLOWING MACHINES ARE NOT ECONOMICAL.

(41.) Because few if any of them are able to use up more than three fifths of the gasoline in cold weather, unless external heat is applied, and this is often attended with disastrous consequences (sec. 53).

AIR-BLOWING MACHINES ARE NOT RELIABLE.

(42.) In using these machines the common practice is *to operate upon large bodies of gasoline at one time.* It has been shown (sec. 12) that whenever a body of gasoline is evaporated the lighter and more valuable portions escape at first, the remainder growing continually heavier until its gravity falls so low that it is no longer fit for use. In a word, from the moment you commence to use a barrel of gasoline in one of these machines *its gravity begins to fall.*

(43.) The necessary consequence of this constant deterioration of the liquid in the machine must inevitably be a proportionate deterioration in the quality of the gas produced. This is not felt very much in summer, when the temperature of the atmosphere is sufficiently high to vaporize the lowest grades of gasoline, and when but a few lights are burned, and these only for a few hours at a time. But it becomes a serious matter in winter, when for the greater part of the time the temperature is so low that it scarcely suffices to vaporize the lighter grades of gasoline, and when, moreover, the nights are long and a great number of lights are used and for many consecutive hours (secs. 22 and 23). Indeed, a careful inquiry will establish the fact *that any gas machine which operates upon large bodies of gasoline at one time cannot be relied upon to make gas for any continuous length of time in large quantities, or of uniform quality.*

(44.) If the quality of the gas be affected by the gravity of the liquid, it must be equally so by the temperature of the air (sec. 16). You need scarcely be told that *the quality of your gas* will depend upon *the quantity of vapor* generated and absorbed by the air in its passage over or through the gasoline. Consequently, where atmospheric evaporation is relied on, as it is in air-blowing gas machines, the quality of your gas must be influenced by every change of the temperature of the atmosphere. *Therefore, a machine which is not independent of atmospheric changes cannot make*

gas of a uniform quality, and cannot be looked upon as reliable.

(45.) If the quality of the gas be injuriously affected by atmospheric changes, *how much more must it be influenced by the great depression of temperature which takes place not only in the air, but even in the gasoline itself, in consequence of the cold produced by its own evaporation* (secs. 22 and 23). Where a person has a large machine and burns but a few lights, and these only for a short time, these effects are not felt to any great extent, for the *small amount of vapor formed* cannot absorb heat sufficient to lower the temperature of *the large body of gasoline within the machine* to any great extent, and then there will probably be an interval of eighteen or twenty hours during which there will be no lights burned, and the liquid will have time to recover from the surrounding air the caloric it has lost the previous night.

(46.) A man will put a fifty-light machine into his house, and very likely will seldom burn more than ten lights, consequently he gets all the light he wants and gets along very well with his machine. *This is no test.*

(47.) If you wish to test a gas machine, put on the full number of burners it is rated at, and see whether it will run for twenty-four or even twelve hours *continuously and without any change in the quality of the gas. No air-blowing machine ever made could stand such a test without the aid of external heat,* for the intense cold produced within it by the rapid and continued evaporation (secs. 22 and 23) would stop the production of gas and put the lights out in half the time. *We need scarcely add that a fifty-light machine which is unable to supply gas for fifty or forty or even thirty lights for any continuous length of time is not reliable.*

(48.) You cannot expect to make gas *at a uniform rate of production or of uniform quality except under uniform conditions. How is it possible for these to exist in machines in which the gravity of the gasoline and the temperature of that as well as of the air are continually and unavoidably changing? How can you expect any result but failure, if your machine is not constructed so as to preserve a uniform gravity of the one and a uniform temperature of both?*

APPLICATION OF HEAT.

(49.) These causes of failure have been long felt and understood, and gas machine makers have tried to remedy them by one ingenious device or the other. Many feed the gasoline to their machines from convenient reservoirs, and in quantities of a few gallons at a time; and some *have attempted, and only attempted, to supply the caloric lost by evaporation, by the application of ex-*

ternal heat, the cause of their failure being inability to control the extent of the evaporation and consequent quality of the gas.

(50.) It must be remembered that a definite amount of heat applied to the gasoline will be certain to produce a proportionate amount of evaporation, without any regard to the number of burners in use. Now, if you light fifty burners, and by any suitable application of heat succeed in maintaining your gasoline at a uniform temperature, your gas will be of uniform quality, at least so far as it is affected by the temperature, and so long as the number of burners in use continues the same.

(51.) Suppose now you turn off ten burners, the evaporation proceeds just as rapidly as when all were lighted, and consequently your gas is too rich, and smokes. Turn off ten or fifteen more burners, and matters become worse; for not only do the lights smoke worse than before, but the slightest depression of temperature causes the precipitation, or, as it is usually called, the *condensation* in the pipes of a large amount of the vapor with which the air is overcharged.

(52.) How will it be if you turn off all the lights but five or six? Why your gasoline will give off just as much vapor as when you were burning fifty, and, instead of having your pipes filled with vapor and air in the proper proportions, you will have them filled with nearly pure vapor, and consequently you will be troubled with smoky lights, and an enormous amount of condensation.

(53.) This has been the cause of many sad accidents; for whenever a large amount of condensation takes place, *as it is sure to do under the circumstances just described*, it is very likely to occur that some of the chandeliers or other pendant lights will get filled with liquid, so that when the burners are turned on and a match applied they will most probably spout the burning gasoline over the person and furniture.

(54.) The truth of the matter is, nobody has yet found out how *to heat the body of gasoline in the machine* so as to make it give off the exact amount of vapor required, whether for one burner or fifty. *Consequently these air-blowing machines in which it is attempted to supplement the atmospheric temperature, by the application of external heat, are no better than those which rely solely upon the temperature of the air itself, and may be pronounced far more unsafe and equally unreliable. They can make gas well enough, but they are a failure, an absolute failure,* BECAUSE THEY AFFORD NO MEANS OF CONTROLLING THE PROPORTIONS OF AIR AND VAPOR, AND CONSEQUENT QUALITY OF THE GAS.

THE MAXIM GAS MACHINE.

(55.) The reader of the foregoing pages will scarcely be surprised to learn, that the history of the portable gas machine business has hitherto been an unbroken record of failures, disappointment and pecuniary disaster, not only to the purchasers but also to the manufacturers of machines, as will be attested by the hundreds who have been ruined in the vain endeavor to build a legitimate business upon the manufacture of machines, in many, if not most instances, designed and constructed by parties ignorant of the first principles involved, and as will be also attested by the many thousands who have unsuccessfully tried not only one, but several machines successively, and, after all, have been compelled to give up gas and return to lamps and candles.

(56.) This was pretty much the state of the gas machine business, when in 1866, Mr. Hiram S. Maxim, who for many years had been engaged in designing and constructing many of the leading gas machines, and who had thus an excellent opportunity of studying their several peculiarities and defects, determined to leave the beaten track and endeavor to turn to account these chemical and physical laws to the agency of which others had owed their failure.

(57.) As has been already stated, he saw that the air-gas machine makers who had endeavored to supplement the atmospheric temperature by the application of external heat were upon the right track, inasmuch as they had thus made themselves independent of atmospheric changes (Secs. 16 and 48), and he justly ascribed their failure (Secs. 51 to 54) *not to their having applied heat, but to their not being able to control its effects; not to the fact of their having generated vapor by the application of heat, but to their failure to devise some means of mixing this vapor in the proper proportion with air.*

(58.) After long and patient experiment, Mr. Maxim at length succeeded not only in controlling the proportions of the mixture of vapor and air, but also *in utilizing the pressure of the vapor itself* as a power not only to *supply* the amount of air required, but also *to control and regulate with absolute and unerring certainty* the proportions of vapor and air, and consequent quality of the gas, the result being the MAXIM GAS MACHINE, in the interest of which this pamphlet is written, and which is claimed to be *the only practical and reliable air-gas machine ever constructed.*

CONSTRUCTION AND OPERATION OF THE MAXIM MACHINE.

(59.) THE MAXIM GAS MACHINE is the only one constructed upon the principle described (Sec. 6), *and is claimed to be the only*

air-gas machine which is *completely independent* of atmospheric changes, and which is constructed so as to control and regulate with absolute and unerring certainty the proportions of vapor and air, and consequent quality of the gas. It is also claimed *to be the only portable gas machine which is perfectly safe, reliable, economical, durable, compact and simple.* Let us now see whether this is so; let us examine in detail the construction and operation of the machine; let us see whether it has or has not overcome the difficulties to which other machines owe their failure, and let us inquire whether it combines within itself the requirements of a good gas machine as laid down (Sec. 26).

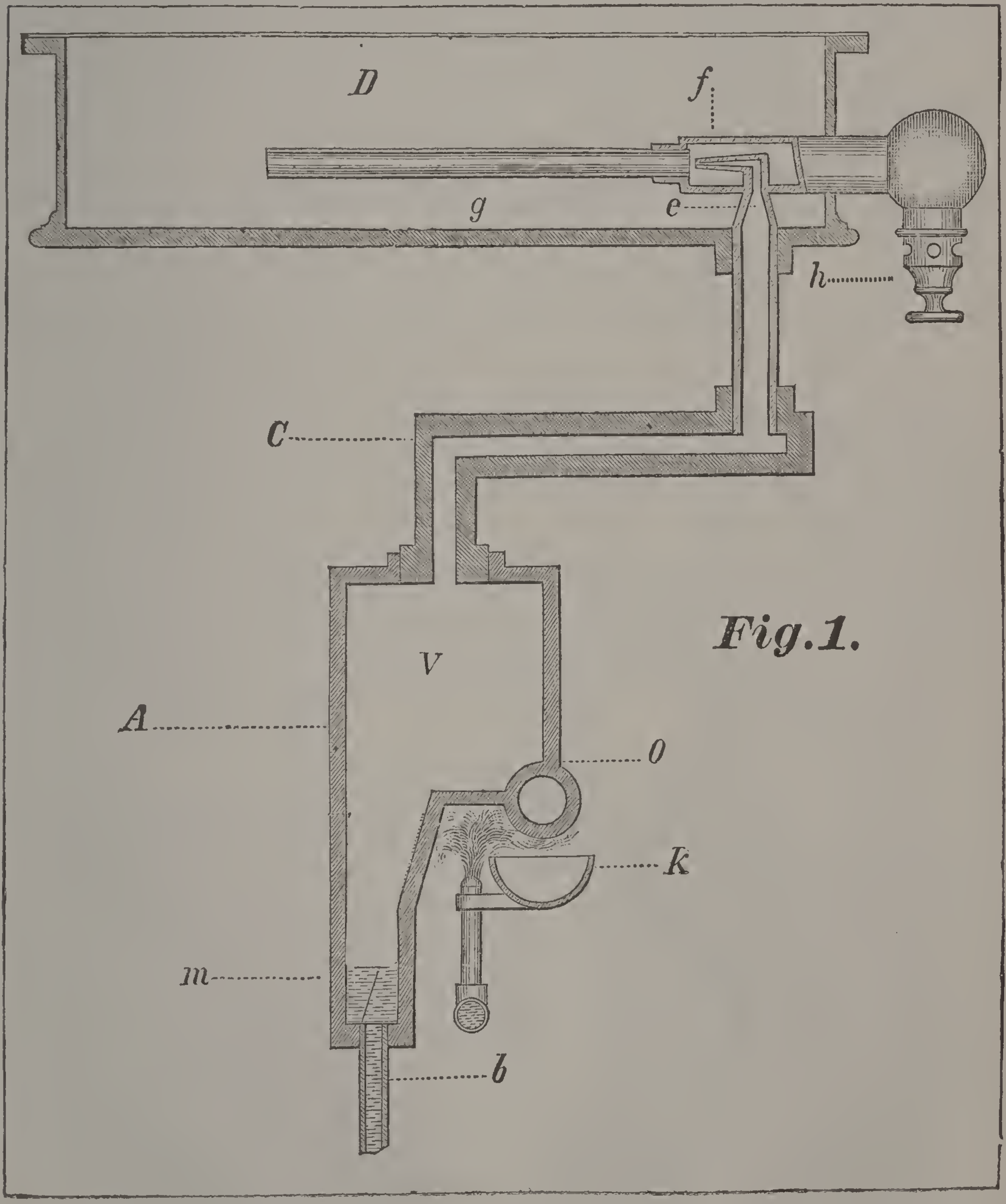


Fig. 1.

(60.) The following description and plates will sufficiently explain the construction and operation of the machine, *figure* 1 being a vertical section of the top or diaphragm, and jet, with the retort and connecting pipe; and *figure* 2 being a similar section of the gas house showing the method of setting and arranging the machine, tank, &c.

(61.) The heater or retort A is shown as it would appear internally, and will readily sustain a pressure of three hundred pounds. The pipe *b* leads to the supply tank, while that indicated by *c*, connects it with the "top" or chamber *D*, used as a reservoir or gas holder, and covered by an air tight, flexible diaphragm, which, by rising or falling, operates a valve at *e*. This valve and the mechanism which operates it are not shown. When the machine is cold, and not in operation, the gasoline in the supply tank, influenced by the air pressure (which we will call 30 lbs. to the square inch), fills the heater up to the valve *e* with a pressure of 30 lbs. The machine is started by igniting alcohol in the cup *k*, and when the heat created is sufficient to form vapor under 30 lbs. pressure, the gas begins to collect at *c*, and as the heat increases, the liquid is forced back against the 30 lbs. pressure in the tank, until it stands at the point *m*, leaving the space *v* filled with vapor at a high tension, and under a pressure of 30 lbs. *which, however the heat may be increased, it can never exceed*, for the slightest excess of pressure forces the liquid back though the connecting pipe into the tank, thus *removing it from the heat* and establishing an equilibrium of pressure between the gas in the retort and the compressed air in the tank. Under the pressure of 30 lbs., or thereabouts, the gas is forced through the jet *f*, into and through the pipe *g*, so as to form a vacuum and induce a sufficient supply of air through the air valve *h*, *figure* 1. The gas is now ready for use, and is forced into the pipes by the pressure of a weight upon the flexible diaphragm on top of the chamber *D*.

INDUCTION.

(62.) The principle of induction is simply this: that a liquid or vapor forced at a high velocity through a small jet and directed through a larger opening *induces*, that is to say, carries in with it a larger volume of any intervening fluid. In the Maxim Gas Machine the inductive power of a jet of vapor forced at a high velocity through a small opening, and directed into the mouth of a pipe, induces and carries with it a large volume of air, thus taking the place of the old fashioned, cumbrous pump, its complication of wheels, its wire ropes and enormous driving weight. Not only does it do this, it goes further and affords a certain and unerring means of regulating and controlling the proportions of vapor and air, so as to furnish gas of any desired quality, *and maintain that quality unchanged for any desired length of time*, with the machine running to its fullest capacity,

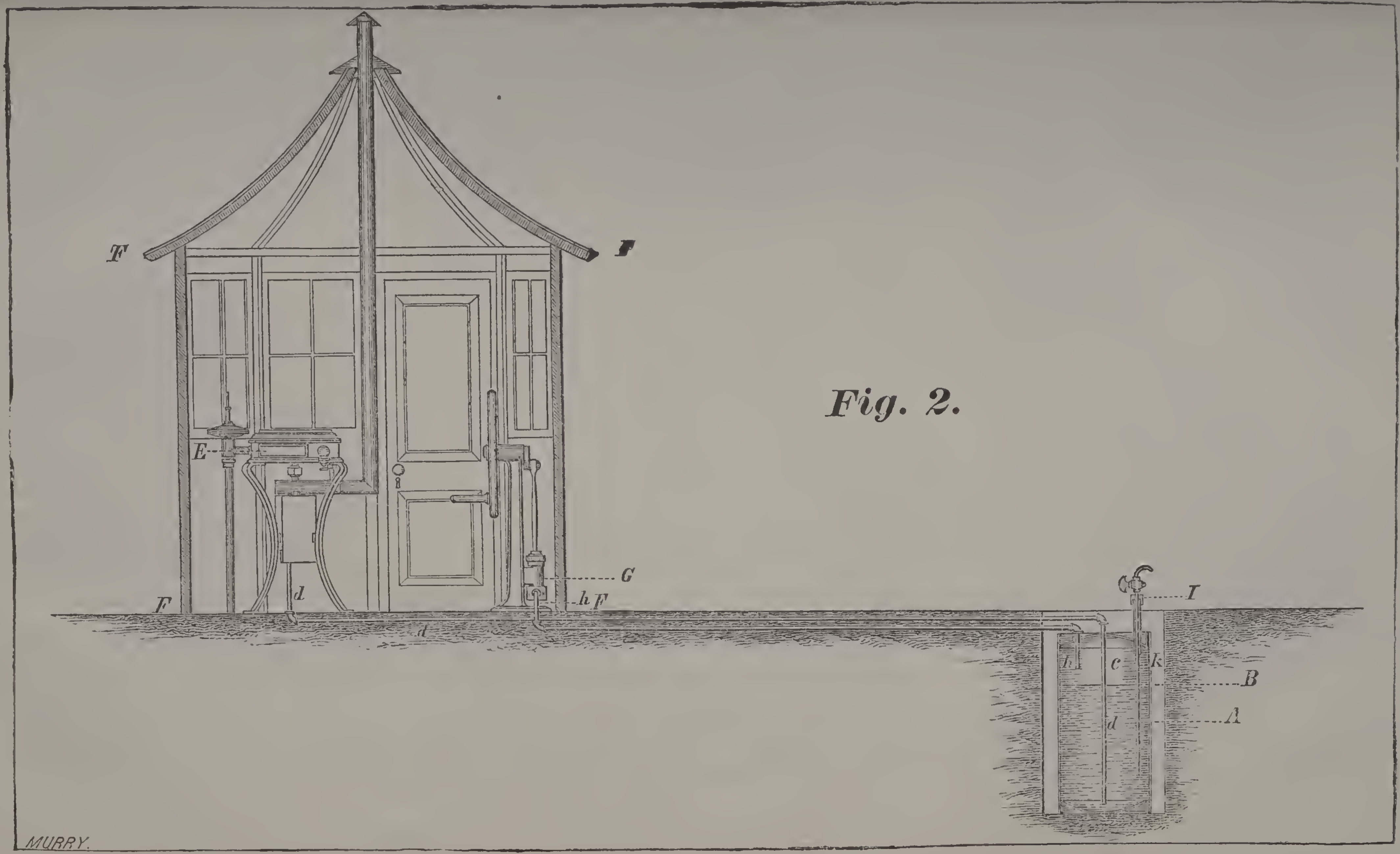


Fig. 2.

THE MAXIM MACHINE IS SAFE.

(63.) Let us now see whether in its construction and operation the Maxim Machine comes fully up to the standard laid down (Sec. 26). As shown in fig. 2, the tank containing the gasoline is placed *not only outside the building to be lighted but even outside the building containing the machine itself*, and is buried in the ground. This tank is tested to stand a pressure of 150 lbs.—five times as much as it is ever subjected to—and instead, as has been customary, of building vaults which are simply reservoirs for explosive gases, it is covered up in the ground, so that even if a leak should occur, there would be no place around it for the accumulation of gas, and even then it is placed in the open air outside of any building, so that even if an accident did occur it could not do any harm.

(64.) It has been already stated that air is forced into a tank until a pressure of 30 lbs. is reached. This air is used *for pressure only*, so that hydrostatic pressure will suit equally well where it is available. Immediately upon being forced into the tank it becomes so highly saturated with the vapor of the gasoline in the tank *that it will not even burn, much less explode, without the further addition of twice its volume of pure air.* Now, in case a leak should occur in the tank, and the escaping gas, as it may now be called, should take fire, it would merely burn just as if it issued from a large burner, *but no fire could possibly enter the tank against the pressure of the escaping gas*, any more than it could enter an ordinary gas pipe through the burner; so that at least, as far as the tank and the supply of gasoline it contains are concerned, the Maxim Machine may be regarded as safe.

(65.) The contrary is the case with air-blowing machines, for the best of them are constructed so that a vacuum may be formed within the machine by a hitch in, or an accident to, the driving weights or pulleys, or by the breaking of the wire rope, the consequence being *that in case of fire being brought near the machine it would be sucked into it, and most probably would cause an explosion.*

(66.) It may here be said that the Maxim Machine cannot be safe because fire is applied to gasoline, which is just the same as applying it to so much gunpowder. The answer is, that gunpowder contains within itself the oxygen necessary to its complete combustion and explosion, and will surely explode as soon as it is heated to a certain temperature. Gasoline contains no oxygen whatever, *so that you may heat its vapor to a white heat without either burning or exploding it, provided you confine it in a close vessel so as to exclude the air;* and it must be remembered that the retort in which the gasoline is heated is capable of standing a pressure of 300 lbs. to the square inch.

How much safer is this than a kerosene lamp? Most of the kerosene sold is largely adulterated with naphtha; and it is well known that the presence of one quart of naphtha in a barrel of kerosene oil will render the mass nearly as explosive as if it was all naphtha; yet no person has any hesitation about using this oil in a thin glass lamp, where the flame is brought within two or three inches of the fluid, while in the machine the gasoline is completely excluded from communication with the fire, and is confined in a retort so strong that there is no possibility of bursting it. Again, the lamp is filled every day within doors, and is liable to be broken at any moment in being carried about the house; while the gasoline tank requires to be filled but every two or three months, and this outside of any building, and there is no carrying round of an explosive compound in a glass vessel and with a light burning within a few inches of it.

(67.) It has been already stated that the retort, though required to stand a pressure of but 30 lbs., is made of sufficient strength to stand 300 (Sec. 61). When in operation the machine never contains more than a gill of gasoline. The tank will stand a pressure of 150 lbs., is placed outside of any building, and is filled in daylight at intervals of two or three months, and as an additional element of safety is provided with an automatic valve, so constructed that in case of a break or other accident to the supply pipe or the machine itself it would instantly close the tank so as to prevent the further escape of a single drop.

(68.) It must not be forgotten that a most essential element of safety in the Maxim Gas Machine is, that as all the gasoline is used up, there is no residuum to be drawn off, and there is no filling or handling of gasoline to be done in the house or at the machine itself, and a reference to the report of the Committee on Gas Machines of the New York Board of Fire Underwriters, adopted October 20th, 1869, will show that hereby the chief element of danger is removed.

CAUTION.

(69.) In what has been said of the safety of the Maxim Gas Machine, there is no intention whatever of deceiving or misleading any person as to the really dangerous nature of gasoline. On the contrary, the greatest care in handling it cannot be too earnestly recommended to those who use it. *No handling, or filling, or emtying of gasoline should be done within doors upon any pretext whatever, and never by any chance should any of these be done by the light of a lamp or candle, or in the neighborhood of fire of any sort.* But here, *with the gasoline itself and the handling of it, the danger ends.* In the management and use of the machine itself there is no more danger than there is in the use of a stove; and the Maxim Gas Machine Company claim, that with ordinary

care and prudence, it is as safe as any man can reasonably expect, and furthermore, *that it is the safest gas machine ever made.*

THE MAXIM MACHINE IS PERFECTLY RELIABLE.

(70.) Because by the application of heat it becomes practicably independent of atmospheric changes, as well as the refrigerating effects of evaporation (Secs. 23, 44 to 47), *for the heat necessary to the formation of vapor is drawn from an external source*, and consequently the machine is capable of running to its fullest capacity for any desired length of time without the slightest falling off in the quantity or quality of the gas produced.

(71.) It may be said, however, that other machines can employ heat as well as the MAXIM, and consequently must be equally reliable. To this it may be answered, *that the application of heat to other machines is a failure, because they apply it to the main body of the gasoline, and because they afford no means of regulating the quantity of vapor formed or of mixing it in proper proportions with air* (Secs. 49 to 54), *while by means of its air valve the* MAXIM MACHINE *can regulate and control these proportions with the greatest nicety. In air-blowing machines the amount of vapor absorbed by the air is a mere matter of chance* (Sec. 54), *while in the* MAXIM *the proportions of vapor air and consequent value and permanency of the gas can be regulated to a certainty, so that they will be always the same without the slightest change whether you are using one burner or fifty, or whether you run the machine for one or two, or fifty consecutive hours.*

(72.) It is well known that in air-blowing machines the practice is to operate upon large quantities of gasoline at one time, and it has been shown (Secs. 12 and 13) that the effect of this is, that the gravity of the gasoline, and consequently its value for making air-gas, *must undergo a constant deterioration*, in consequence of the fractional distillation to which it is subjected. In the MAXIM MACHINE the gasoline is admitted to the retort through a small pipe in infinitesimal quantities and only as it is used. All the gasoline that enters the retort is completely used up, and none can return to the tank to reduce the gravity of the remaining liquid *which remains always the same, without the slightest change, until the last drop is used up.*

BURNERS.

(73.) In addition, the MAXIM is the only air-gas machine which is adapted to using the ordinary bats-wing burner. The reason of this is, that it is a rule that a very rich gas requires to be burned through a small burner and under a high pressure, so that being expelled from the burner with some velocity it may

become largely mixed with air, and thus diluted *at a point very close to the tip of the burner*, while gas of a medium quality, requires to be burned through a burner of medium size and under a medium pressure, and poor gas requires a large burner and a very low pressure. Now it has been shown that the quality of the gas made by air-blowing machines must unavoidably undergo a constant change (Secs. 12, 21 and 22), and *that these machines cannot possibly make gas of uniform quality at any two periods from the time of putting a charge of gasoline into the machine, until as much of it as it is capable of utilizing is used up;* consequently, the burner which will suit the gas made by them at one time will not suit that made at another, and *as a matter of necessity* they are compelled to use the Argand burner, which is the only one adapted to burning *all qualities of gas, both rich and poor, equally well.*

(74.) It has been shown *that the* Maxim Machine *is capable of making gas of any desired quality, and retaining that quality unchanged, without any regard to atmospheric changes, to the number of burners in use, or the number of hours they are kept lighted; consequently, the gas manufactured by it, being always of the same quality, admits of being used in the ordinary bats-wing burner.*

SUMMARY.

(75.) *Taking into consideration these facts: That the* Maxim *is* THE ONLY MACHINE *which is perfectly independent of atmospheric changes; that it is* THE ONLY MACHINE *which is capable of regulating and controlling exactly the proportions of vapor and air, and consequent quality of the gas; that it is* THE ONLY MACHINE *which is capable of maintaining the quality of the gas unchanged, with the machine running to its fullest capacity, and for any desired length of time; that it is* THE ONLY MACHINE *which draws its gasoline from the tank in infinitesimal quantities, and allows none to return, so that the remaining liquid continues always of the same gravity, and without the slightest deterioration, until the last drop is used up, and that it is* THE ONLY AIR-GAS MACHINE *which makes gas with which the ordinary bats-wing burner can be used,* IT MAY BE FAIRLY PRONOUNCED NOT ONLY TO BE PERFECTLY RELIABLE, BUT ALSO TO BE THE ONLY RELIABLE AIR-GAS MACHINE EVER MADE.

THE MAXIM MACHINE IS ECONOMICAL, DURABLE, COMPACT AND SIMPLE.

(76.) That the Maxim Gas Machine *must be economical* is

evidenced by the fact that it never leaves any residuum, every drop of the gasoline being used up. *That it is compact* is shown by its small size—a machine capable of running five hundred lights, occupying a space not more than two feet square by four feet high; and *that it is durable and simple* any person can satisfy himself, from the fact that it contains but one or two moving parts, and these capable of being replaced at any time at a trifling expense; whereas, the old air-blowing machines require a large blowing-wheel, with an expensive complication of cog wheels, pullies and ropes, which are constantly breaking and getting out of order.

CONDENSATION.

(77.) It is often asked—Is the gas made by the Maxim Machine liable to be condensed in the pipes in cold weather? To which it may be answered that all illuminating gas, even the best coal gas, is in some measure liable to condensation in cold weather, and as a rule the richer any gas is, the more apt it is to condense. Therefore when it is asserted that *the gas made by the* Maxim Machine *is not liable to condensation*, the meaning is, *that practically it is not;* that it is subject to condensation very little, if any, more than coal gas, which it is well known is not affected by cold so much as to cause practical inconvenience.

(78.) It may be said that this is not so; that in cold weather all air-gas condenses to an enormous extent, and that the gas made by the Maxim Machine can be no exception to this rule.

(79.) It has been found by repeated experiments that when air-gas is passed very slowly through a coil of pipe immersed in a freezing mixture *the air will retain in solution vapor sufficient to give a good light.* There is no doubt whatever but that if an excess of vapor be present such excess will be *precipitated*, or, as it is commonly called, *condensed* as a liquid; but there is just as little doubt that at any temperature to which it may be reduced, the air will carry and retain in solution sufficient vapor to give a good light (sec. 24 and 25).

(80.) If now, the gas as it leaves the machine is at the temperature of 70°, Fahrenheit, and the machine be constructed and adjusted so as to prevent the air from taking up more vapor than it can hold in solution at 32°, it is very evident that if the temperature of the gas be reduced to 32°, there can be no condensation. For it must be remembered that it is only the *excess* over what the air is capable of holding in solution that is precipitated, or condensed.

(81.) Now the machine has been adjusted so that the air cannot be charged with more vapor than it is capable of holding in solu-

tion at 32°. *The air becomes charged with this quantity of vapor and no more.* There is sufficient vapor present to give a good light, but there can be no condensation, for it must be remembered that it is only *the excess* over the amount of vapor that the air is capable of holding in solution which condenses. In the present instance the machine has been adjusted so that *there cannot be present any excess of vapor* over what it is capable of holding in solution at 32°; therefore if the temperature be reduced to this point *there cannot be condensation for there is no excess to be condensed.*

(82.) It has been shown that the Maxim Gas Machine is the only one the construction and operation of which is such as to control, regulate and limit with the most unerring certainty the proportions of hydrocarbon vapor with which the air is charged (sec. 71), and therefore *it may be safely claimed to be the only machine capable of making air-gas which is practically free from condensation.*

PIPING.

(83.) All large coal-gas companies usually prescribe a scale of piping which they require to be conformed to, the following being that usually adopted:

Size of Pipe.	Maximum Length Allowable.	Number of Burners.
$\frac{1}{4}$ inch	6 feet	1 light.
$\frac{3}{8}$ "	20 "	3 "
$\frac{1}{2}$ "	30 "	6 "
$\frac{3}{4}$ "	50 "	20 "
1 "	70 "	35 "
$1\frac{1}{4}$ "	100 "	60 "
$1\frac{1}{2}$ "	150 "	100 "
2 "	200 "	200 "

(84.) In cities, gas companies usually inspect the piping before supplying gas, and require the above scale to be strictly conformed to; but in piping country houses, and especially when the work is to be done by contract, gas fitters very frequently pay very little attention to it.

(85.) The Maxim Gas Company *warrant their machines to give a good uniform light through every part of any house piped according to the above scale;* but whenever a building is to be piped specially for air-gas they would recommend the adoption of a scale one size larger than the above—$\frac{3}{8}$ for $\frac{1}{4}$ inch, and corresponding length of pipe and number of lights, and the rest in proportion. They would also recommend particular attention to the following rules:

(86.) Never use less than inch *riser* for any house.

(87.) The underground pipe leading from the machine to the house should be at least one size larger than the riser.

(88.) Wherever it can be done, bracket lights should run *up from the running pipe.*

(89.) All running pipes should have an inclination of about one inch in fifty feet toward the machine.

(90.) It is desirable that all connections made from running pipes should be made from the *side* or *top*, instead of from the *bottom* of the pipe.

FIXTURES.

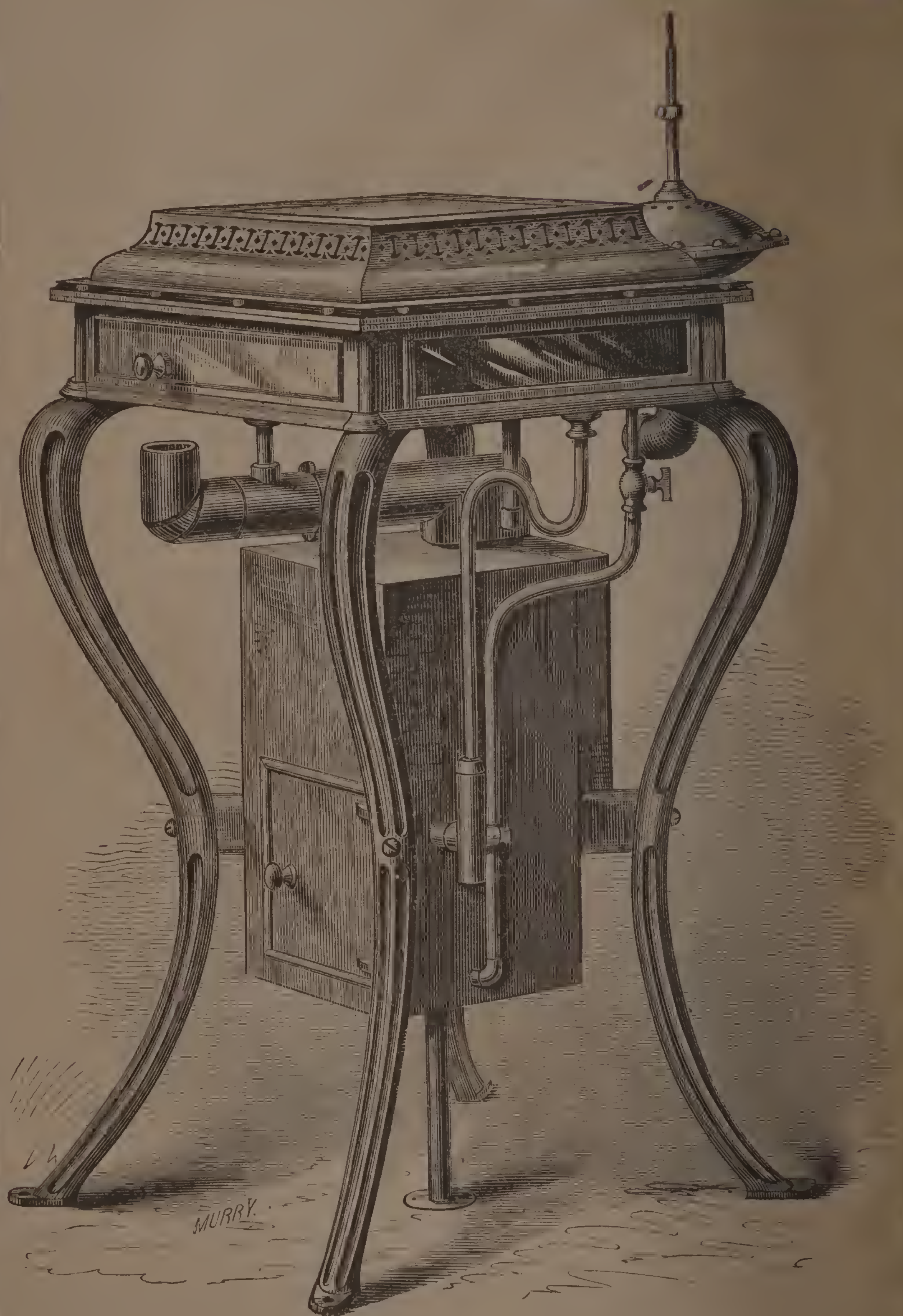
(91.) Most coal-gas fixtures will suit for air-gas, but of course some will suit better than others; consequently it is advisable before purchasing to consult those who are acquainted with the peculiarities of the gas, and either buy from them or obtain directions as to the best kind.

(92.) The Maxim Gas Machine Company are prepared to contract to pipe buildings, or make necessary alterations, as also to supply fixtures from selected patterns, and *at the lowest prices.* They are also prepared to furnish machines, upon trial, to responsible parties, to whom they will allow a reasonable time to satisfy themselves of their efficient and satisfactory working before being asked for payment.

Those desiring further information, either from business motives or otherwise, are cordially invited to inspect the working of the machine at the office of the

MAXIM GAS MACHINE CO. OF NEW YORK,

294 Broadway.


MURRY.